BOTANICAL MUSEUM LEAFLETS
HARVARD UNIVERSITY

Cambridge, Massachusetts, November 21, 1969 Vol. 22, No. 7

A NEW AMAZONIAN ARROW POISON: *OCOTEA VENENOSA*

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A recently discovered ingredient of arrow poisons used by the Kofán Indians of the westernmost Amazon in Colombia and Ecuador is produced by an undescribed species of *Ocotea* of the Lauraceae.

Ocotea venenosa *Kosterm. et Pinkley sp. nov.*

Arbor ramulis cum innovationibus dense minutissime ferrugineo-pilosis; foliis spiraliter alternantibus vel sub-oppositis, chartaceis, ellipticis, obscure acuminatis, basi in petiolum brevem contractis supra laevibus, nervo mediano prominulo, costis filiformibus vix prominulis, subtus dense prominule reticulatis, nervo mediano prominenti, dense pulverulente piloso, costis utrinque ca. 9 subpatentibus prominulis; inflorescentiis paniculatis, axillaribus, parvis, dense minutissimeque ferrugineo-pilosis; floribus tantum in alabastrum cognitis; tepalis ovatis; staminibus fertilibus 9, crassis, exterioribus loculis 4 magnis, introrsis, filamentis crassis, interioribus loculis 4 extrorsis; glandulis non vidi; ovario subpiloso, ellipsoideo, in sty-

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lum brevem prodeuntibus; fructu depresso-globoso, magno in cupulo magno incluso.

COLOMBIA: Comisaría del Putumayo, Río Guamúes, Santa Rosa. Primary forest. Altitude about 1060 feet. Long. 77°05′ W, Lat. 00°19′ N. November 26, 1966. *H.V. Pinkley 555* TYPE! (TYPE in Herb. Gray. DUPLICATE TYPE in Econ. Herb. Oakes Ames; Utrecht; Naturhistoriska Riksmuseet, Stockholm).—ECUADOR: Provincía del Napo, Río Aguarico, Durero. "Fruit used to make arrow poison. Wood, yellow, very hard and bitter to taste. Sterile". October 26, 1966. *H.V. Pinkley 538*.

Tree 32 m., bole 20 m., diam. 70 cm.: branchlets and terminal bud densely and minutely rusty-pilose. Leaves spirally arranged, occasionally subopposite, chartaceous, coriaceous, glabrous except above the midrib underneath, elliptical or narrowly elliptical, 6–9×16–20 cm. obscurely acuminate, base contracted into petiole 8–12 mm. long, flattened above; upper surface smooth, glossy, midrib conspicuous, prominent, lateral nerves filiform, hardly prominent; lower surface glossy, densely, minutely, and rather obscurely reticulate. Midrib prominent, densely pulverulent-pilose, lateral nerves ca. 9 pairs, rather patent, slightly arcuate, prominent. Panicles (immature) axillary, up to 2 cm. long, densely, minutely rusty-pilose. Flower buds ca. 1.5 mm. in diam.; tepals ovate, fleshy, acutish, equal, or the inner ones narrower. Fertile stamens 9, thick, 4-celled; outer ones with large introrse and introrse-lateral cells, the anther not differentiated from the thick filament; the inner row with similar but narrower stamens with extrorse cells; the connectives blunt, protruded beyond the cells. Glands not seen. Ovary and style as long as the stamens, the ovary ellipsoid, merging into a slightly shorter style with rather inconspicuous stigma. Fruit depressed-globose, 5.5 cm. diam., 4.5 cm. high, smooth, with a small notch at the apex; cup 1 mm. thick, obscurely, broadly ribbed, covering the entire fruit except the upper part, leaving an orifice of 2.5 cm. diam.; the cup closely adpressed to the fruit. In a smaller fruit (4.5 cm. diam.) the orifice of the cup is 3.5 cm. in diam. Stalk thick, woody, very short, 6 mm. diam.; cotyledons plane-convex, thick; plumule, and radicle basal.

Most of the flower buds available for dissection were abnormal as a result of fungal attack. The fruit cup is unusual in *Ocotea*, because it is almost adnate to the fruit. Another peculiarity is that the fruit does not protrude from the cup. This is rare in *Ocotea*, but it does occur in other genera of the Lauraceae.

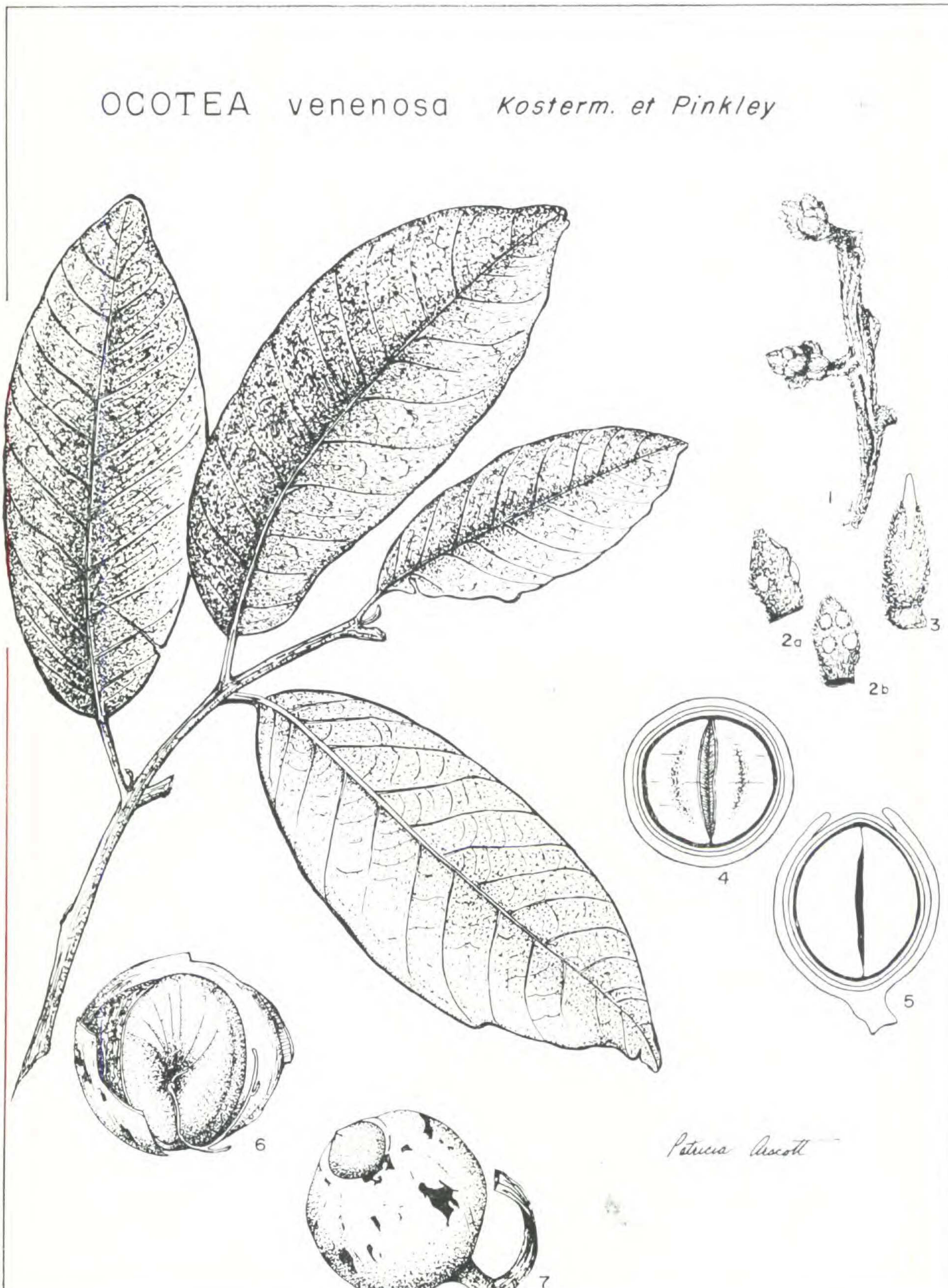
The Kofán Indians, a tropical rain forest tribe of eastern Ecuador and Colombia, employ the fruit of this plant, *gïngïvéʔk'o* in Kofán, as an ingredient in one of their arrow poisons. Hence, the specific epithet, which means "very poisonous" in Latin, was chosen for this large tree. Two trees had to be felled before fertile material was found. After felling the first tree, which was sterile, I (Pinkley) took bark of the tree to my hut, thinking that it was the part of the tree used in preparing the arrow poison. When I arrived with the bark, the Indians laughed and revealed that they use only the fruit.

Chemical analysis and pharmacologic research of this new species is being carried out by Dr. Ara Der Marderosian of the Philadelphia College of Pharmacy and Science. He reports, through personal communication, that he has isolated two of several alkaloids present, rodiasine and demethylrodiasine related to the curare alkaloid of medicine, d-tubocurarine. Rodiasine was first isolated in crystalline form from *Ocotea Rodiei* (Rob. Schomb.) Mez (*Nectandra Rodiei* Rob. Schomb.), (4, 7). The alkaloid study of *Ocotea Rodiei* began much earlier, however, when Maclagan in 1843 separated the alkaloids of this plant into two amorphous fractions, calling the portion soluble in ether bebeerine, and the portion in-soluble in ether sepeerine. Since Maclagan's classic study, the name bebeerine, however, has been variously defined resulting in much confusion (7). Since he isolated amorphous fractions rather than crystalline compounds, most are in favor of abandoning his nomenclature and using coined names referring only to actual isolated compounds. Hence, though Maclagan's bebeerine may be, in fact, the same or related to rodiasine, the term rodiasine is now preferred. Maclagan was encouraged to study the chemistry of *Ocotea Rodiei* not because of any known curarizing effect but because the wood was known to be highly resistant to insects, marine borers and fungal decay (5, 8). Today we know that curine, the *l* form of "bebeerine," in high concentration ". . . causes paralysis of the striated muscles and paralysis of the nerve end plates" (6). Though the chemical constituents of *Ocotea venenosa* and *Ocotea Rodiei* appear to be similar, the initial chemical investigations were induced for two different reasons.

Several plants of the Lauraceae with an alkaloid related to "bebeerine" were reported in 1890 by Greshoff, a pioneer in phytochemistry. Greshoff found in several genera an alkaloid which he called "lauro-tetanine." He stated that (transl.), "according to the important characteristic, . . . causing tetanus in several species of animals, I propose to give this body which can be crystallized and characterized by good reactions the name lauro-tetanine" (3). He furthermore recognized the similarity of laurotetanine and bebeerine and suggested that (transl.) "a detailed quantitative research of bebeerine seems one of the most urgent desiderata of the alkaloid studies" (3).

Other alkaloids with curarizing effects have been isolated from the lauraceous tree *Cryptocarya Bowiei* (Hooker) Druce of Australia (2). The poisonous nature of this plant was discovered, quite by accident, by T. L. Bancroft in 1886. He related his experience: (1)

PLATE LXIV



Ocotea venenosa. Habit sketch of branchlet, $\times \frac{1}{3}$. 1, inflorescence branchlet, $\times 2$. 2a, outer stamen, $\times 15$. 2b, inner stamen, $\times 15$. 3, ovary and style, $\times 20$. 4, diagrammatic cross section of fruit, $\times \frac{1}{3}$. 5, diagrammatic longitudinal section of fruit, $\times \frac{1}{3}$. 6, oblique angle of dissected fruit showing large cotyledon and developed root, $\times \frac{1}{3}$. 7, fruit, $\times \frac{1}{3}$.

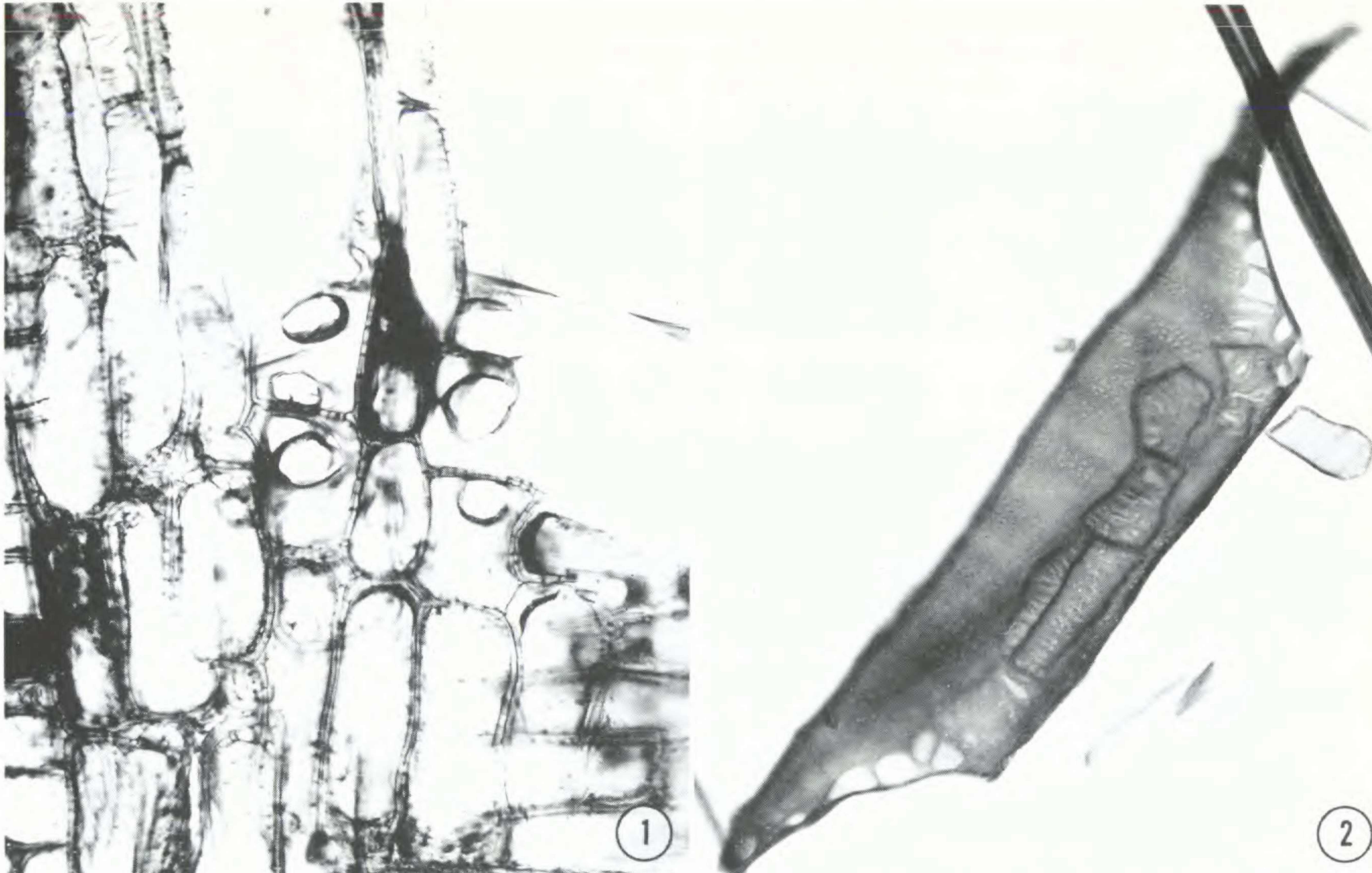
On May 12th, 1886, in search of poisonous plants I found the bark of this tree to have a very persistently bitter taste. Physiological experiments were immediately made, which led to the discovery of its toxic action. Other species of the same genus are likewise poisonous. It is interesting botanically to note such a poisonous genus in this order.

The alkaloid or its salts have an intensely bitter taste; it is odourless and extremely poisonous, slightly soluble in water, very soluble in alcohol, ether, and chloroform. Warm blooded animals poisoned with Cryptocarya exhibit respiratory difficulty, soon ending in asphyxial convulsions and death. On frogs it causes paralysis of the reflex function of the spinal cord and the peripheral ends of motor nerves as effectually as curara.

The fact that Bancroft was led to make further studies because of the very persistent bitter taste has an interesting parallel among the Kofán Indians. Most, if not all, of the plants which they use in preparing arrow poisons are bitter. Equally true, one of the first diagnostic characters used by the Kofáns in identifying a plant is its taste. After first tasting the bark of a tree, for example, they will look up into the forest canopy and try to find leaves associated with the tree. It is quite possible that bitterness, *inza'tsi* in Kofán, led to the original discovery of the plants used for their arrow poisons. Moreover, in many cultures bitterness has become associated with death. An association which may have resulted from primitive man's observation that many bitter plants can cause death.

Xylem Anatomy of *Ocotea venenosa*

Pores are decidedly rounded and occur mostly in the solitary (76%), radial multiple (20%), and clustered (4%) distributions. Radial multiples usually comprise only 2 pores, 3- and 4-pored multiples being rather uncommon. Only 3-pored clusters were noted. Tangential pore diameter ranged from 87μ–155μ with an average of 117μ, based on measurements of 50 pores. Vessel elements all



1, radial section of xylem showing fenestriform pitting between vessel elements and xylem parenchyma, ×290. 2, coronated vessel element from macerated material illustrating fenestriform pits at ends, ×140. Note: Perforations in this vessel element are out-of-focus.

contain simple perforations. Occasional vessel elements with three perforations were noted. Ligules may be present and are usually short or they may be absent from the ends of vessel elements. Intervascular pitting is alternate; inner apertures of pits are horizontally elongate and are enclosed by borders which may be elongate, rounded, or polygonal; adjacent inner apertures may be crossed or coincident. Vessel elements range in length from 235μ–935μ and average 564μ in length, based on 50 measurements.

The relationship between vessel elements and axial and ray parenchyma cells presents a curious if not unique situation in this species. Both kinds of cells are interconnected with adjacent vessel elements through unilaterally compound pitting with very large simple pits in parenchyma cells subtending two or more bordered pits in vessel elements. The large simple pits in the parenchyma cells are often traversed by branched or simple filiform processes of cell wall material. In addition to the unilaterally compound pitting, half-bordered pits occur. Supplementing these more or less common kinds of pitting is the pitting in the coronated vessel elements. These vessel elements are normal in appearance in all respects except that upper and lower ends bear a complete or partial ring of large, fenestriform, obscurely bordered pits which give the impression of a crown or corona (Plate LXIII, fig. 2). These are associated with simple pits of similar size and form in adjacent ray and axial parenchyma cells (Plate LXIII, fig. 1). Pits of the corona may be square, rectangular, triangular, oval, elliptical, or irregular. At times these pits occur on ligules as well. The uniqueness of this pitting resides in its position at upper and lower ends of vessel elements, its vessel element encircling tendency, and the large size of the pits. All combine to impart a crown-like appearance to the ends of vessel elements

For all intents and purposes, the imperforate tracheary elements are libriform wood fibers. Inner apertures of pit-pairs are somewhat elongated and outer apertures are nearly circular. A minute, insignificant border may be observed under high magnification in some pits of some fibers. Walls are very thick ranging up to 8μ. Lumina are equal to or less than the diameter of the walls and are often completely occluded by the growth of the secondary cell walls. Fiber length ranges from 750μ–1437μ and averages 1104μ, based on 50 measurements.

Vascular rays range from 1–4 cells wide, 1-seriate and 4-seriate rays being rare. Ray height ranges from one cell to over 25 cells, most rays being lower than 15 cells high. Rays are heterocellular with the terminal ray cells being square, squarish, or upright and with the body of the ray comprising only procumbent cells. Terminal ray extensions are ordinarily one or two cells high with uniseriate extensions rarely reaching five or six cells high. These cells are slightly swollen as viewed in tangential section.

Axial parenchyma is always paratracheal and may consist of a vasicentric sheath one to several cells wide around vessels and vessel groups; it may be aliform with short, broad wings; or sometimes it is even aliform-confluent.

No secretory cells were observed in the secondary xylem.

Because of the unusual nature of some of the morphological features of *Ocotea venenosa*, namely, the fruit, the third author felt that an investigation of the secondary xylem might be instructive. Other than the exceptional coronated vessel elements described above and the somewhat unusual absence of secretory cells, at least in the specimen examined, the xylem of *O. venenosa* falls well within the range of the xylem anatomical characteristics of Lauraceae described by Stern in 1954 (9). In that work, several species of Lauraceae were noted as lacking secretory cells in the secondary xylem, namely : *Dehaasia triandra*, *Lindera Benzoin*, *Nectandra coriacea*, *N. globosa*, *Neolitsea Levinei*, and *Ravensara crassifolia*. Secretory cells were described as scarce in *Ocotea palmana*, *Hypodaphnis Zenkeri*, and *Laurus nobilis*. The absence of secretory cells in the secondary xylem of *O. venenosa* cannot alone be used to rule out or render questionable the demonstrated taxonomic affinities of this species.

The peculiar fenestriform pitting in vessel elements represents a unique specialization occurring only in this particular species, at least as far as is presently known. Whether or not the combination of the unusual fruit (for *Ocotea*, anyway) and the special coronated vessel elements are significant enough characteristics upon which to base a new genus of Lauraceae, will depend upon the judgment of taxonomists.

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